Ecosystem Service Assessment is reaching businesses and policy, so where are the next challenges for science?

Wolfgang Cramer

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1. A personal history of global change
2. Ecosystem service assessment, an established paradigm?
3. Interfacing science and policy: is the IPCC a blueprint for IPBES?
4. Gaps of knowledge and what to do about them
5. My personal wish list

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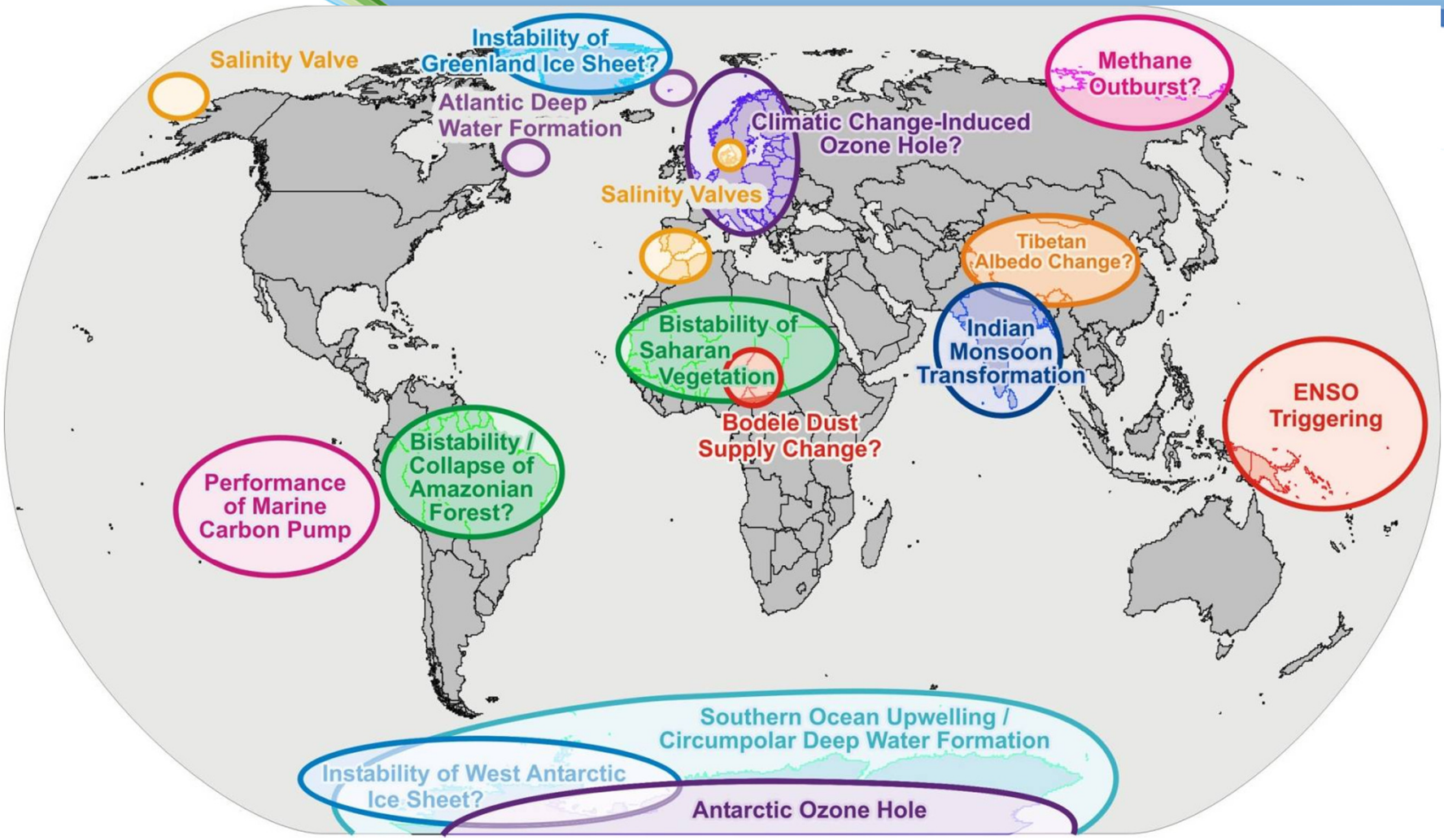
1) A (short) personal history of global change

(prehistory: silent spring, acid rain, Club of Rome)

- The West Antarctic Ice-Shield (1976, H Flohn)
- Anthropogenic climate change (1984, B Bolin)
- The biosphere responds (1990, IIASA)
- The IPCC “line of sight” (1994 onwards)
- Ecosystem services (1997, Costanza)
- Tipping points (2000, HJ Schellnhuber)

Tipping points in the Earth System



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- The anthropocene (2000, Stoermer & Crutzen)

1) A (short) personal history of global change (continued)

- Elbe flood (2002), European Heatwave (2003)

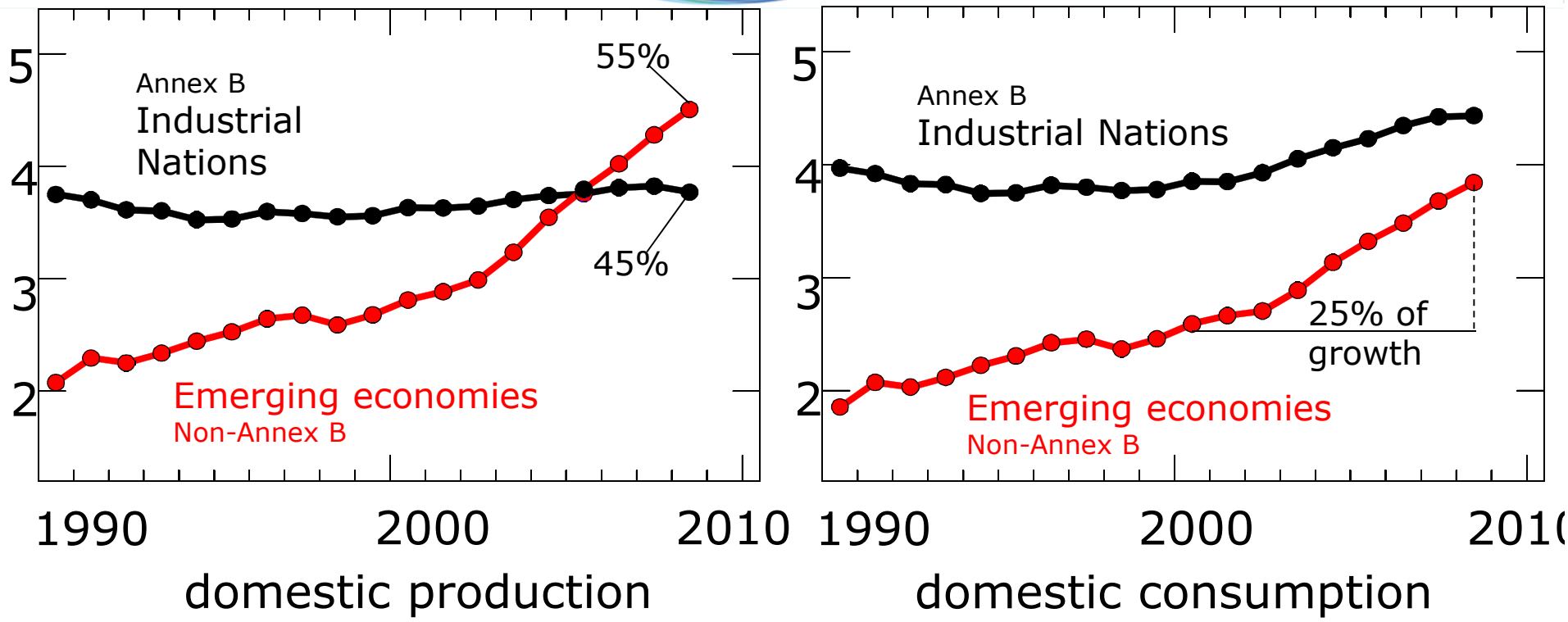

Lorraine, France, August 2003

1) A (short) personal history of global change (continued)

- Elbe flood (2002), European Heatwave (2003)
- Millennium Ecosystem Assessment (2005)
- Damage costs of climate change (2006, N Stern)
- Potsdam Declaration (2007, leading to TEEB, 2010)

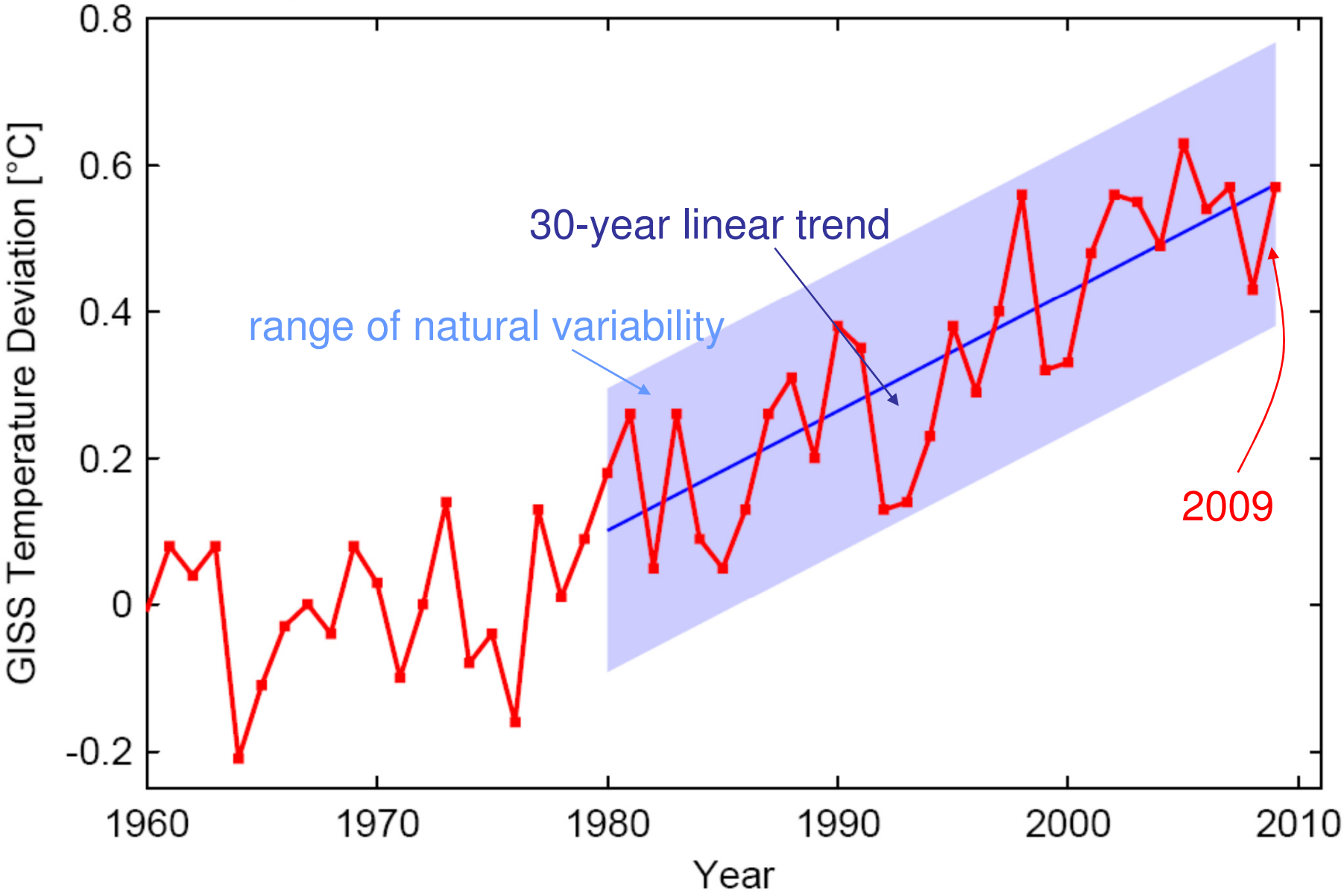
Transport of embodied emissions

CO_2 emissions (Pg C y^{-1})



Global Carbon Project 2009; Le Quéré et al. 2009, Nature Geoscience; Data: Peters & Hetwich 2009; Peters et al. 2008; Weber et al 2008; Guan et al. 2008; CDIAC 2009

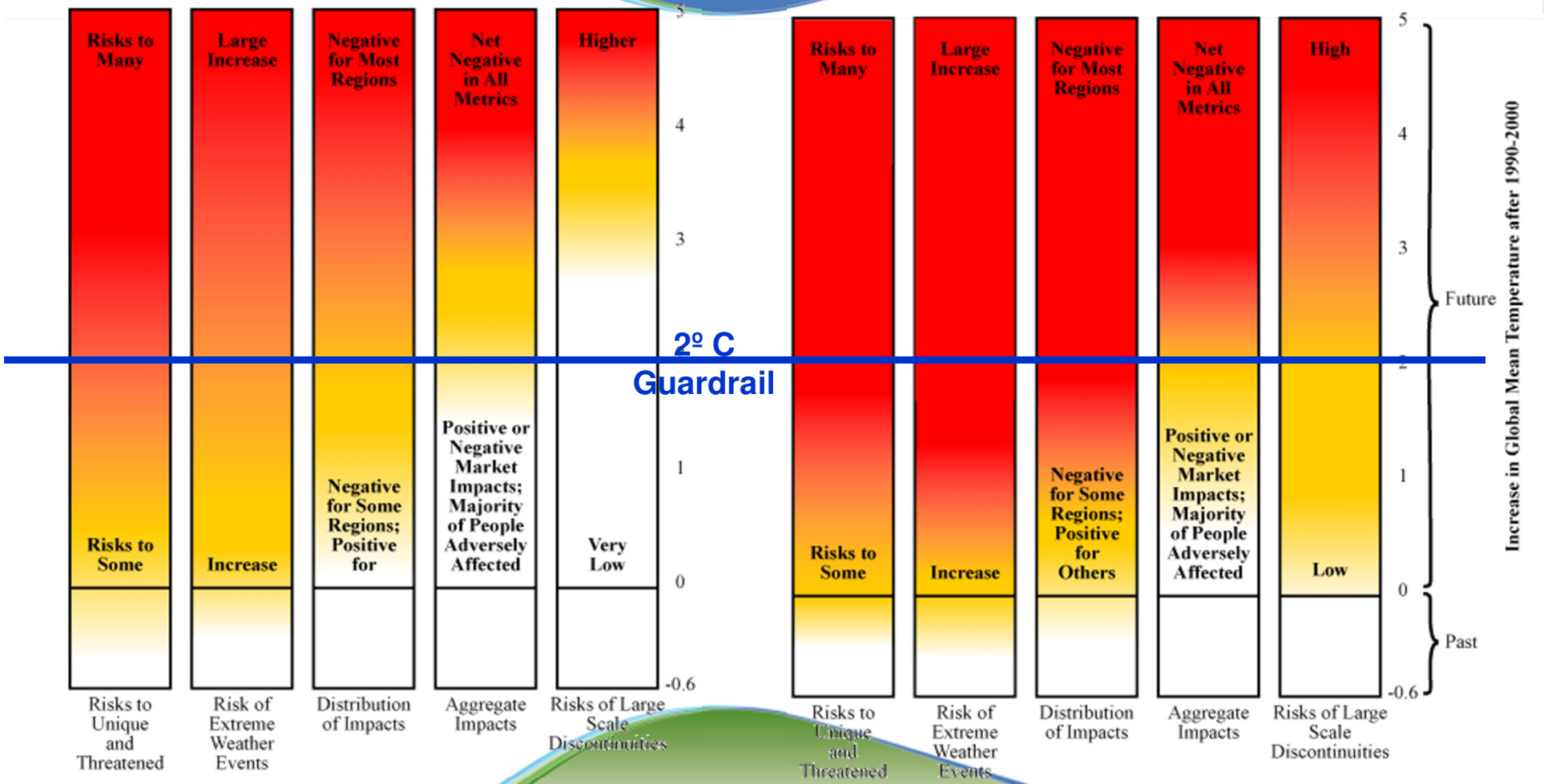
Global temperature



IPCC "Reasons for concern"

IPCC TAR

Smith et al. 2009 (PNAS)



World Population

- 7 billion and counting...
- U.N. wants better life for world of 7 billion
- Population boom heralds global economic shifts
- World awaits 7 billionth baby
- Catholic condom ban not behind population boom
- Billions can be fed, but who will pay the tab?
- Water use rising faster than world population
- Curb soaring population? Keep girls in school
- The next challenge: too few people?
- Slideshow: A world of seven billion
- Video: Africa considers soaring birth rate

MORE REUTERS RESULTS FOR:
"billion"

U.N. wants better life for world of 7 billion

By **Avril Ormsby**

LONDON | Wed Oct 26, 2011 2:29pm EDT

(Reuters) - Instead of worrying about sheer numbers when the world's population hits 7 billion next week,

Related News

Crowded, stretched world awaits 7 billionth baby
Tue, Oct 25 2011

Analysis & Opinion

Trust Tunisia

Europe should avoid eating its seed corn

1) A (short) personal history of global change (continued)

so: does biodiversity really matter?

some people clearly think so:

Transgressing safe boundaries

nature

Vol 461|24 September 2009

FEATURE

A safe operating space for humanity

Identifying and quantifying planetary boundaries that must not be transgressed could help prevent human activities from causing unacceptable environmental change, argue **Johan Rockström** and colleagues.

SUMMARY

- New approach proposed for defining preconditions for human development
- Crossing certain biophysical thresholds could have disastrous consequences for humanity
- Three of nine interlinked planetary boundaries have already been overstepped

Although Earth has undergone many periods of significant environmental change, the planet's environment has been unusually stable for the past 10,000 years[1–3]. This period of stability — known to geologists as the Holocene — has seen human civilizations arise, develop and thrive. Such stability may now be under threat. Since the Industrial Revolution, a new era has arisen, the Anthropocene[4], in which human actions have become the main driver of global environmental change[5]. This could see human activities push the Earth system outside the stable environmental state of the Holocene, with consequences that are detrimental or even catastrophic for large parts of the world. During the Holocene, environmental change occurred naturally and Earth's regulatory capacity maintained the conditions that enabled human development. Regular temperatures, freshwater availability and biogeochemical flows all stayed within a relatively narrow range. Now, largely because of a rapidly growing reliance on fossil fuels and industrialized forms of agriculture, human activities have reached a level that could damage the systems that keep Earth in the desirable Holocene state. The result could be irreversible and, in some cases, abrupt environmental change, leading to a state less conducive to human development[6]. Without pressure from humans, the Holocene is expected to continue for at least several thousands of years[7].

Planetary boundaries

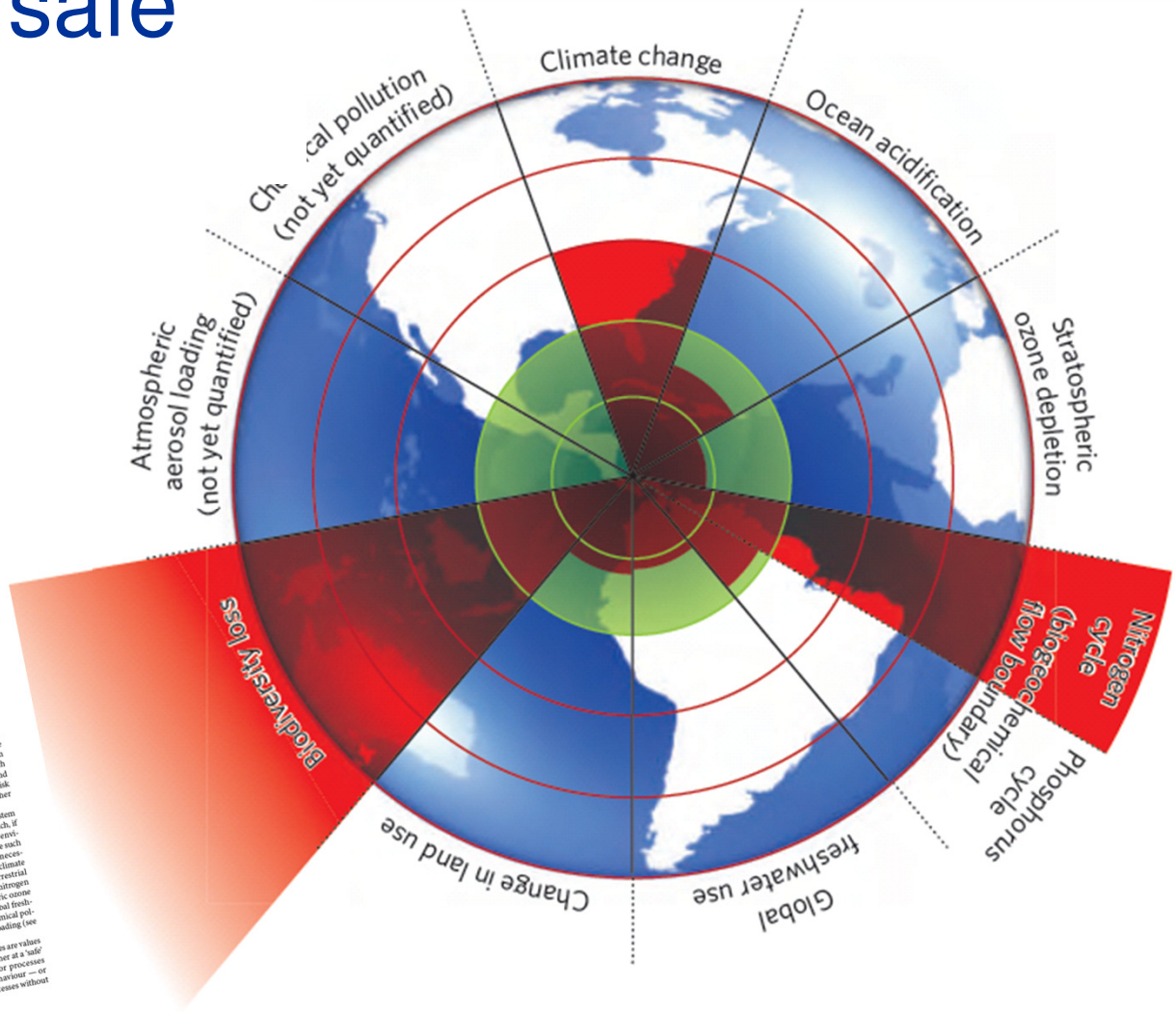
To meet the challenge of maintaining the Holocene state, we propose a framework based on 'planetary boundaries'. These boundaries define the safe operating space for humanity with respect to the Earth system and are associated with the planet's biophysical subsystems or processes. Although Earth's complex systems sometimes respond smoothly to changing pressures, it seems that this will prove to be the exception rather than the rule. Many subsystems of Earth react in a nonlinear, often abrupt, way, and are particularly sensitive around threshold levels of certain key variables. If these thresholds are crossed, then important subsystems, such as a monsoon system, could shift into a new state, often with deleterious or potentially even disastrous consequences for humans[8].

Most of these thresholds can be defined by a critical value for one or more control variables, such as carbon dioxide concentration. Not all processes or subsystems on Earth have well-defined thresholds, although human actions that undermine the resilience of such processes or subsystems — for example, land and water degradation — can increase the risk that thresholds will also be crossed in other processes, such as the climate system.

We have tried to identify the Earth-system processes and associated thresholds which, if crossed, could generate unacceptable environmental change. We have found nine such processes for which we believe it is necessary to define planetary boundaries: climate change; rate of biodiversity loss (terrestrial and marine); interference with the nitrogen and phosphorus cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; change in land use; chemical pollution; and atmospheric aerosol loading (see Fig. 1 and Table).

In general, planetary boundaries are values for control variables that are either at a 'safe' distance from thresholds — for processes with evidence of threshold behaviour — or at dangerous levels — for processes without

Figure 1 | **Beyond the boundary.** The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.



Rockström et al. 2009 Nature, 461 (24): 472-475

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The value of the world's ecosystem services and natural capital

Robert Costanza*†, Ralph d'Arge‡, Rudolf de Groot§, Stephen Farber‖, Monica Grasso†, Bruce Hannon¶, Karin Limburg#☆, Shahid Naeem, Robert V. O'Neill††, Jose Paruelo‡‡, Robert G. Raskin§§, Paul Sutton‖‖ & Marjan van den Belt¶¶**

* *Center for Environmental and Estuarine Studies, Zoology Department, and ‡ Institute for Ecological Economics, University of Maryland, Box 38, Solomons, Maryland 20*
‡ *Economics D 070, USA*
§ *Center for E PO Box 9101, 6700 HB Wageningen, The Netherlands*
‖ *Graduate School of Public and International Affairs, University of Pittsburgh, Pittsburgh, Pennsylvania 15260, USA*
¶ *Geography Department and NCSA, University of Illinois, Urbana, Illinois 61801, USA*
# *Institute of Ecosystem Studies, Millbrook, New York, USA*
** *Department of Ecology, Evolution and Behavior, University of Minnesota, St Paul, Minnesota 55108, USA*
†† *Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA*
‡‡ *Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Av. San Martin 4453, 1417 Buenos Aires, Argentina*
§§ *Jet Propulsion Laboratory, Pasadena, California 91109, USA*
‖‖ *National Center for Geographic Information and Analysis, Department of Geography, University of California at Santa Barbara, Santa Barbara, California 93106, USA*
¶¶ *Ecological Economics Research and Applications Inc., PO Box 1589, Solomons, Maryland 20688, USA*

The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. We have estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US$16–54 trillion ($10^{12}$) per year, with an average of US$33 trillion per year. Because of the nature of the uncertainties, this must be considered a minimum estimate. Global gross national product total is around US$18 trillion per year.

Because ecosystem services are not fully 'captured' in commercial estimate represents a minimum value, which would probably

O. Hobert, *Nature* **430**, 785 (2004).

Acad. Sci. U.S.A. **99**, 9888 (2002).

Ecosystem Service Supply and Vulnerability to Global Change in Europe

Dagmar Schröter,[1,2*] Wolfgang Cramer,[1] Rik Leemans,[3] I. Colin Prentice,[4] Miguel B. Araújo,[5,6] Nigel W. Arnell,[7] Alberte Bondeau,[1] Harald Bugmann,[8] Timothy R. Carter,[9] Carlos A. Gracia,[10] Anne C. de la Vega-Leinert,[1] Markus Erhard,[11] Frank Ewert,[3] Margaret Glendining,[12] Joanna I. House,[4] Susanna Kankaanpää,[9] Richard J. T. Klein,[1] Sandra Lavorel,[13,14] Marcus Lindner,[15] Marc J. Metzger,[3] Jeannette Meyer,[15] Timothy D. Mitchell,[16] Isabelle Reginster,[17] Mark Rounsevell,[17] Santi Sabaté,[10] Stephen Sitch,[1] Ben Smith,[18] Jo Smith,[19] Pete Smith,[19] Martin T. Sykes,[18] Kirsten Thonicke,[4] Wilfried Thuiller,[20] Gill Tuck,[12] Sönke Zaehle,[1] Bärbel Zierl[8]

Global change will alter the supply of ecosystem services that are vital for human well-being. To investigate ecosystem service supply du… century, we used a range of ecosystem models and scenarios o… land-use change to conduct a Europe-wide assessment. Large char… and land use typically resulted in large changes in ecosystem service supply. Some of these trends may be positive (for example, increases in forest area and productivity) or offer opportunities (for example, "surplus land" for agricultural extensification and bioenergy production). However, many changes increase vulnerability as a result of a decreasing supply of ecosystem services (for example, declining soil fertility, declining water availability, increasing risk of forest fires), especially in the Mediterranean and mountain regions.

Mainstream 2004

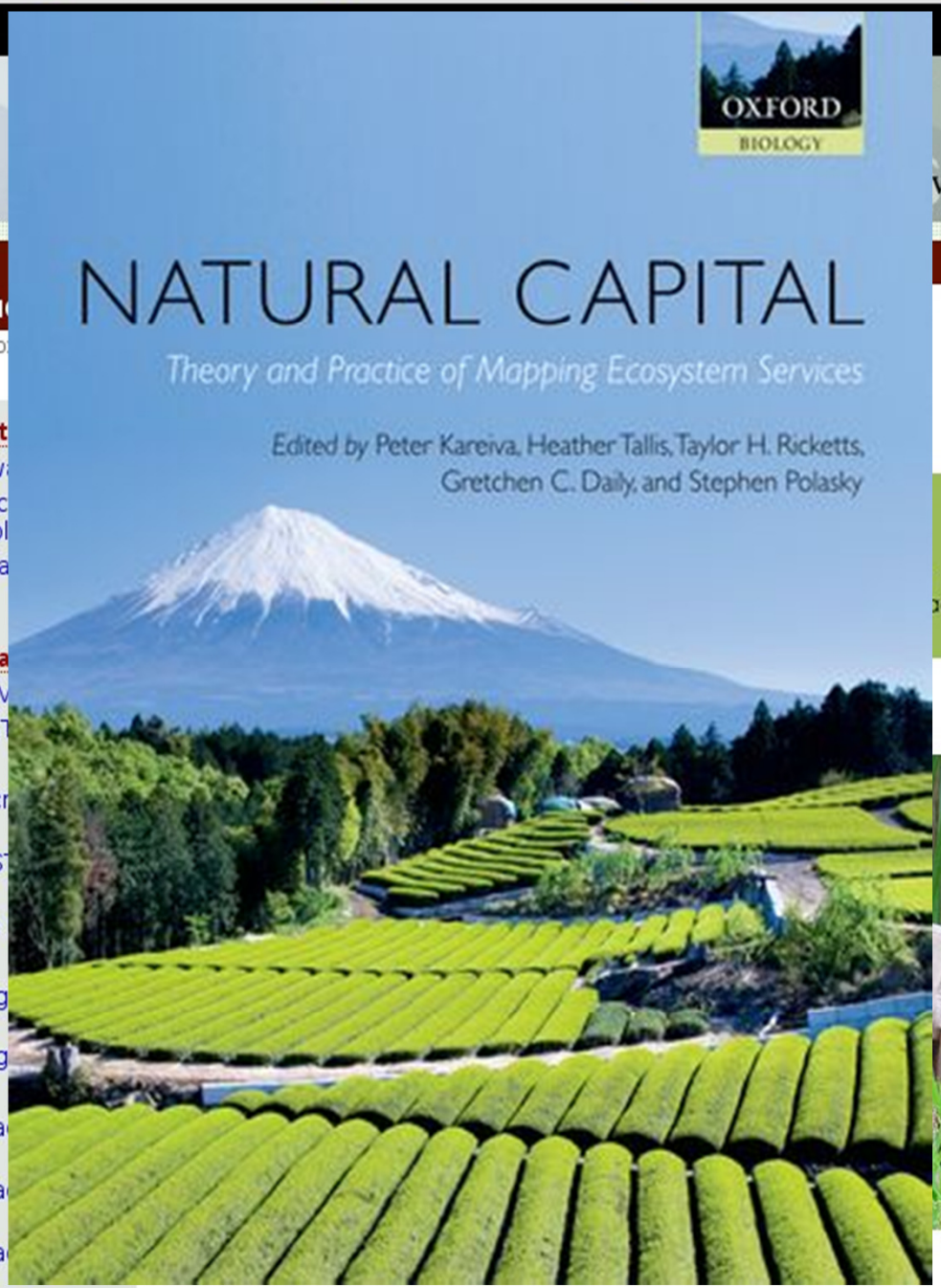
To sustain a future in which the Earth's life-support systems are maintained and human needs are met, human activities must first be recognized as an integral component of ecosystems (*1*, *2*). Scenarios of global change raise

models. A dialogue with stakeholders from relevant sectors was conducted throughout the study (*4*).

Our assessment was based on multiple scenarios for major global change drivers

2080, relative to baseline conditions in 1990 (*5*). Socioeconomic trends were developed from the global Intergovernmental Panel on Climate Change Special Report on Emission Scenarios (IPCC SRES) storylines B1, B2, A1FI, and A2 for EU15+ (*4*, *6*, *7*) (table S1). With this common starting point, socioeconomic changes relate directly to climatic changes through greenhouse gas concentrations and to land-use changes through climatic and socioeconomic drivers, such as demand for food. Four general circulation models (GCMs)—the Hadley Centre Coupled Model Version 3 (HadCM3), the National Center for Atmospheric Research–Parallel Climate Model (NCAR-PCM), the Second Generation

[1]Potsdam Institute for Climate Impact Research, 14473 Potsdam, Germany. [2]Center for International Development, Harvard University, Cambridge, MA 02138, USA. [3]Department of Environmental Sciences, Wageningen University, 6700 AA Wageningen, Netherlands. [4]Department of Earth Sciences, University of Bristol, BS8 1RJ Bristol, UK. [5]School of Geography and Environ… …ord, UK. … Madrid, …esearch, …ampton, Southampton SO17 1BJ, UK. [6]Department of Environmental Sciences, Eidgenössische Technische Hochschule, 8092 Zürich, Switzerland. [9]Finnish Environment Institute, 00251 Helsinki, Finland. [10]Center for Ecological Research and Forestry Applications, University of Barcelona, 08193 Barcelona, Spain. [11]Institute for Meteorology and Climate Research, Forschungszentrum Karlsruhe, 82467 Garmisch-Partenkirchen, Germany. [12]Agriculture and the Environment Division, Rothamsted Research, AL5 2JQ Harpenden, UK. [13]Laboratoire d'Ecologie Alpine, CNRS, Université Joseph Fourier, 38041 Grenoble, France. [14]Centre d'Ecologie Fonctionnelle et Evolutive, CNRS, Montpellier, France. [15]European Forest Institute, 80100 Joensuu, Finland. [16]Tyndall Centre for Climate Change Research, University of East Anglia, NR4 7TJ Norwich, …



natural capital PROJECT

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InVEST in Practice: PRSPs

VATION

adeoffs

The Economics of Ecosystems & Biodiversity

1st Global Business of Biodiversity Symposium

London, 13 July 2010

The Economics of Ecosystems and Biodiversity:

Report for Business

Editors:

Joshua Bishop (IUCN), Cornis van der Lugt (UNEP), Francis Vorhies (Earthmind),

Linda Hwang (BSR), Mikkel Kallesoe (WBCSD), Nicolas Bertrand (UNEP),

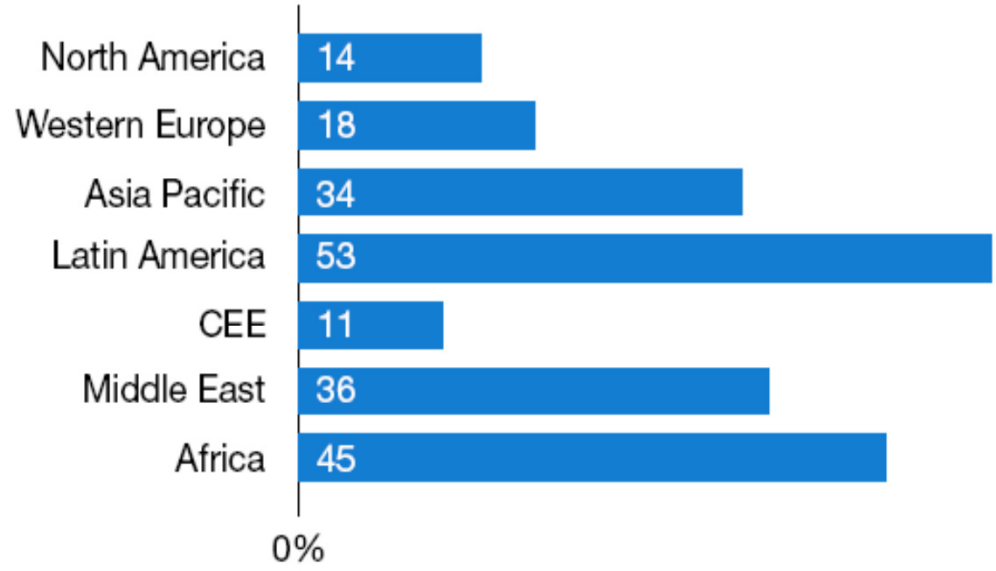
Sean Gilbert (GRI), William Evison (PricewaterhouseCoopers)

Chap 1: Business, biodiversity and ecosystem services (BES)

- The value of nature is changing:
  - Increasing scarcity of natural resources
  - Increasing visibility of ecosystem values
  - More demanding citizens, consumers and public policies
  - New technologies that add value to biodiversity & ecosystems
- All businesses are affected, directly or indirectly
- New and growing BES risks must be managed
- Just as climate change has stimulated new technologies, business models and markets, BES offer opportunities for investors and entrepreneurs

Growing business awareness of BES

Respondents who were 'extremely' or 'somewhat concerned' about biodiversity loss as a threat to their business growth prospects.



Q: How concerned are you about the following potential threats to your business growth prospects?
Base: All respondents (139, 442, 289, 167, 93, 28, 40) Please note small base for Middle East

Source: PricewaterhouseCoopers 13th Annual Global CEO Survey 2010

Chap 4: Scaling down biodiversity & ecosystem risks to business

- **Integrated Biodiversity Assessment Tool**
  - http://www.biodiversityinfo.org/ibat/
  - GIS database for site-level risk assessment
  - Based on World Database of Protected Areas, World Biodiversity Database, IUCN Red List of Threatened Species

- **Business and Biodiversity Offsets Program**
  - http://www.forest-trends.org/biodiversityoffsetprogram/
  - Guidance on designing and implementing biodiversity offsets to ensure “no net loss”
  - Led by Forest Trends, Wildlife Conservation Society and Conservation International

- **Certification and labelling**
  - http://www.isealalliance.org/
  - Global hub for social and environmental standards
  - Members represent fair trade, forest stewardship, organic agriculture, fisheries, etc.

Chap 5:Increasing biodiversity business opportunities

Adding BES to existing business

- Agriculture
- Biodiversity mgmt services
- Cosmetics
- Extractive industries
- Finance
- Fisheries
- Forestry
- Garments
- Handicrafts
- Pharmaceuticals
- Retail
- Tourism

- **New markets for biodiversity and ecosystem services**
- Bio-carbon & REDD
- Biodiversity banking
- Enabling policy & tools

The Economics of Ecosystems & Biodiversity

Main TEEB funders:

and Nuclear Safety

defra
Department for Environment Food and Rural Affairs

UKaid
from the Department for International Development

NORWEGIAN MINISTRY OF FOREIGN AFFAIRS

Rijksoverheid

Sida

TEEB for Busines

(www.teebweb.org)

Main D3 writers:

World Business Council for Sustainable Development

Global Reporting Initiative

CONSERVATION INTERNATIONAL

PRICEWATERHOUSECOOPERS

EARTHWATCH INSTITUTE

BSR

EARTHMIND

UNEP

IUCN

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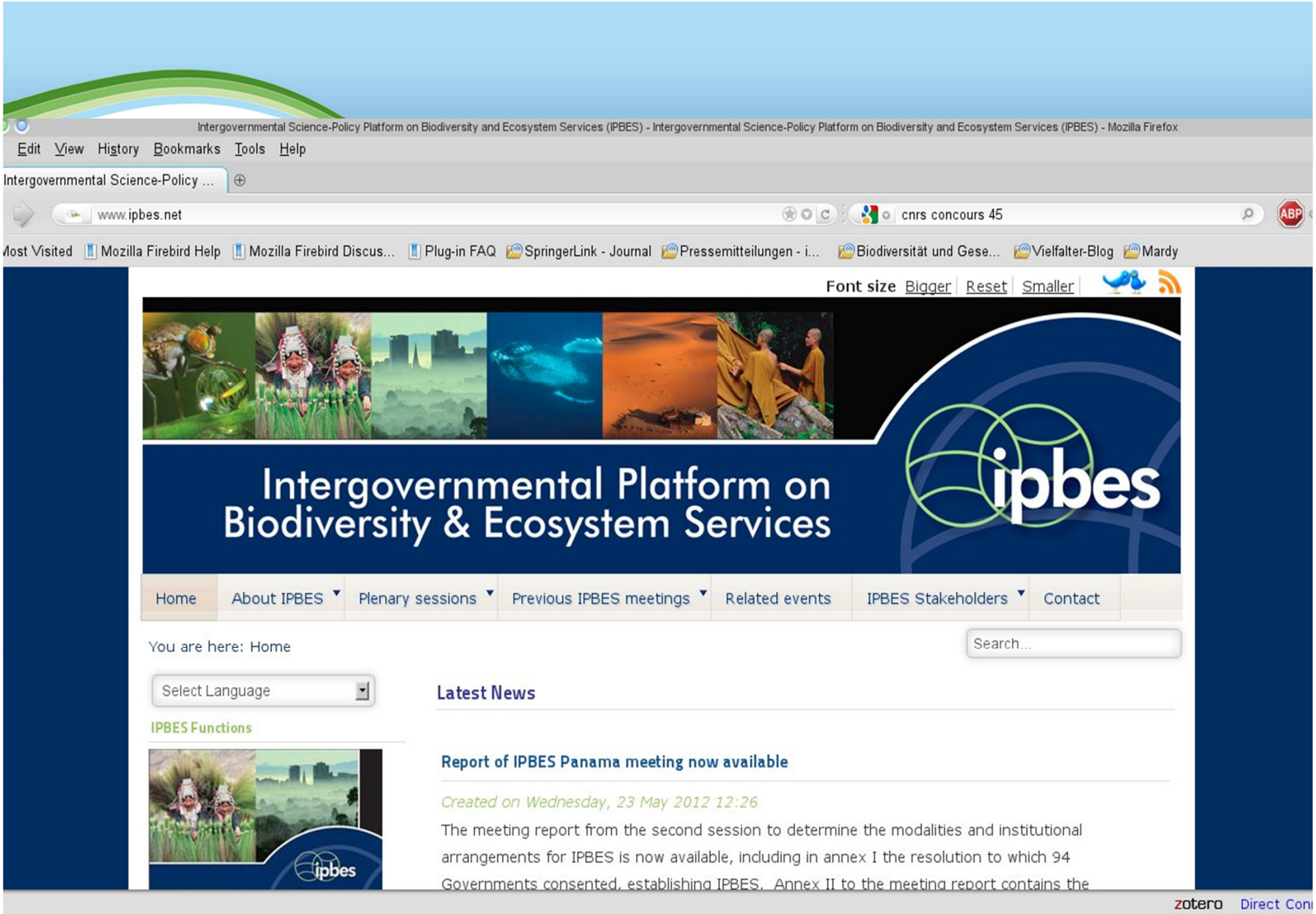
2010 International Year of Biodiversity
Biodiversity is life.
Biodiversity is our life.
"Mr Steiner and I have been chatting. We agreed immediately: Conserving biological diversity has the same dimension and importance as climate change."
(Angela Merkel, 11 Jan 2010, Berlin, Germany)


Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) - Mozilla Firefox
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Report of IPBES Panama meeting now available
Created on Wednesday, 23 May 2012 12:26
The meeting report from the second session to determine the modalities and institutional arrangements for IPBES is now available, including in annex I the resolution to which 94 Governments consented, establishing IPBES. Annex II to the meeting report contains the
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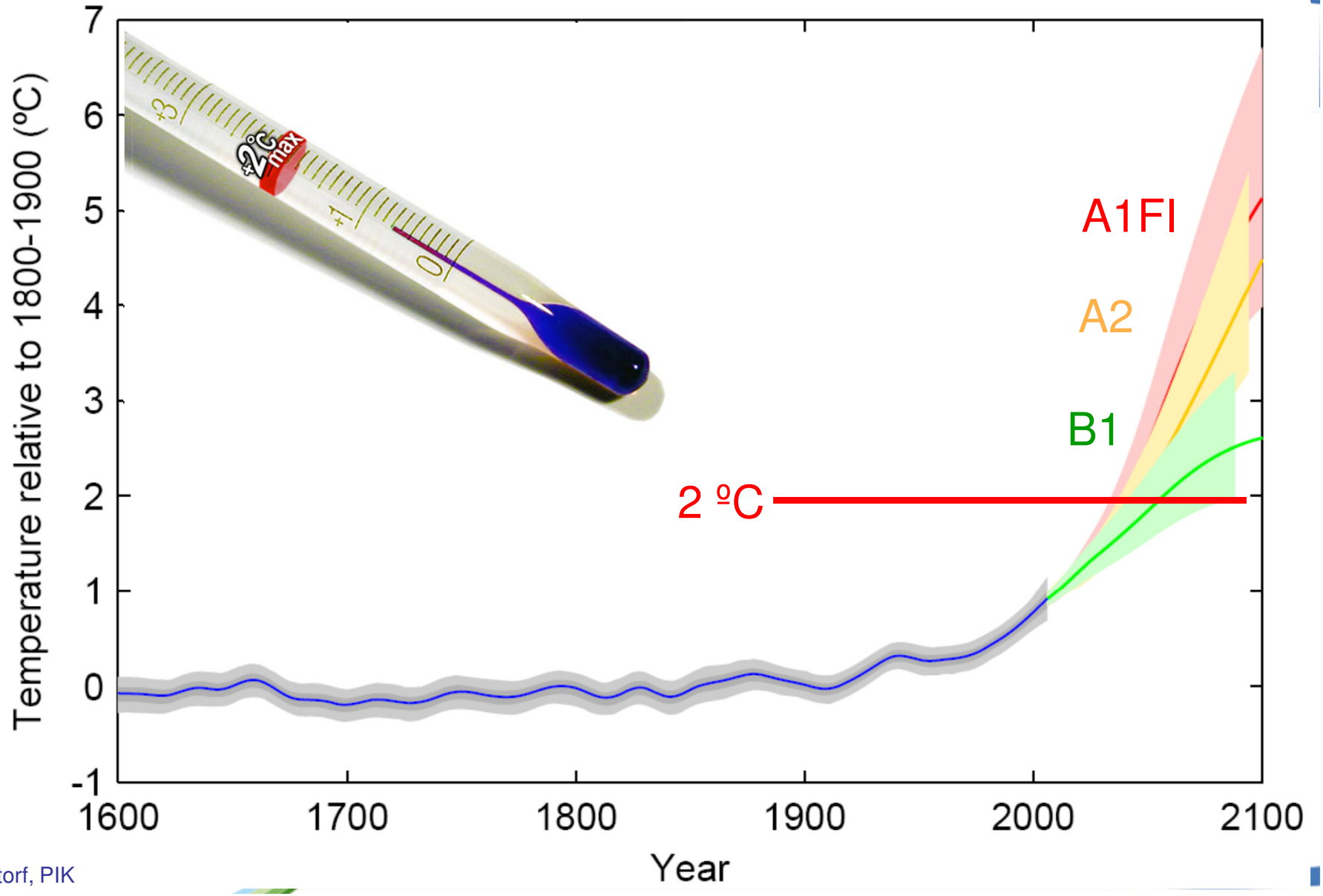
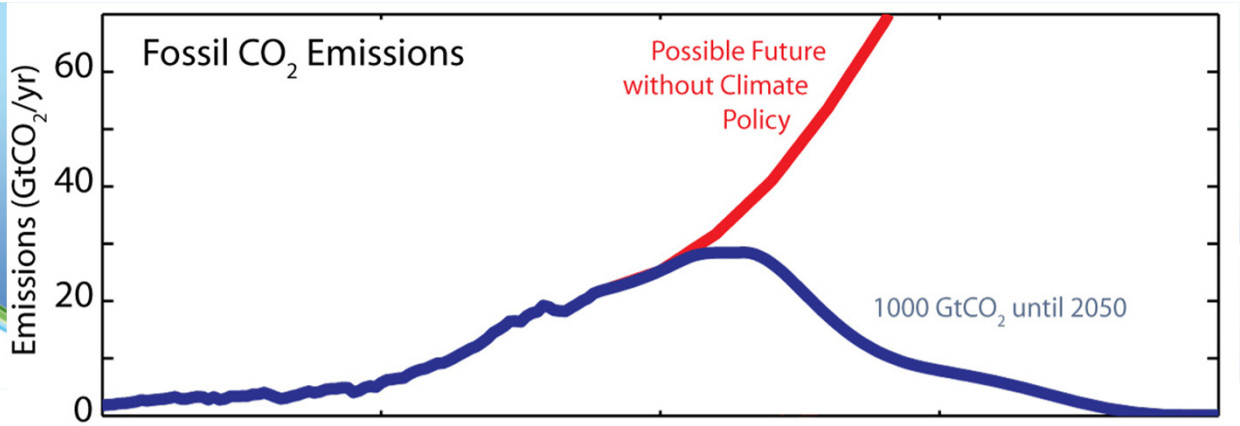
The 2º “guard rail”

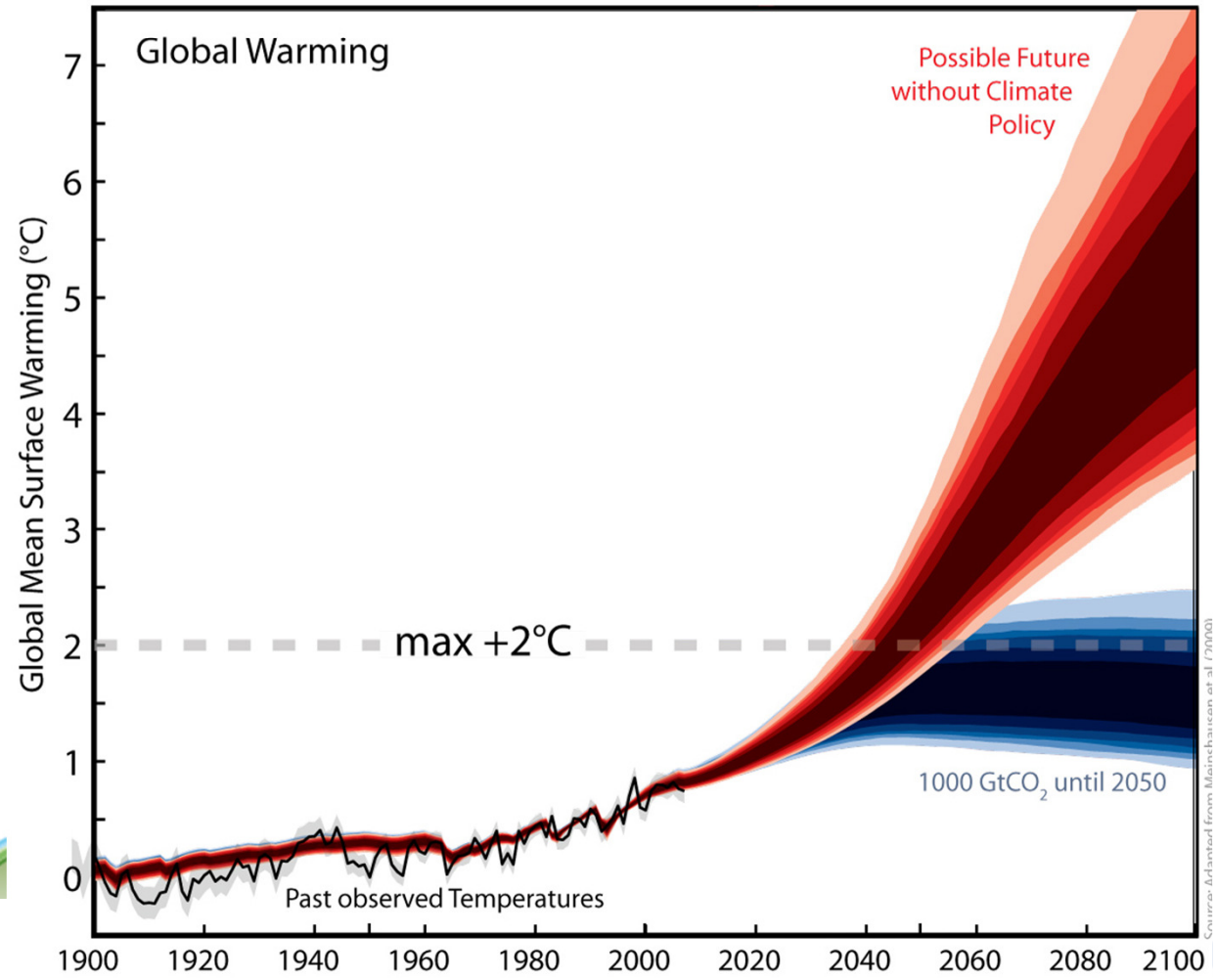


- To stay below 2º (75% probability) we can emit until 2050 approx.

  700 Gt CO_2

- At current rates, this amount will be reached within 20 years.





Meinshausen et al 2009

Similar targets for biodiversity?

The « Aichi biodiversity targets »

Strategic goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity

Target 11: By 2020, at least 17 per cent of terrestrial and inland water areas, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes

Target 12: By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

Target 13: By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives is maintained,

Strategic goal A. Address the underlying causes of biodiversity loss

Target 1: By 2020, … People are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.

Target 2: By 2020, … biodiversity values are integrated into national and local development and poverty reduction strategies and planning processes and national accounts …

Target 3: By 2020, … incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, .

Target 4: By 2020, … Governments, business and stakeholders have plans for sustainable production and consumption and keep the impacts resource use within safe ecological limits.

3) Interfacing science and policy: is the IPCC a blueprint for IPBES?

Yes:

- "Line of sight" to published literature
- Very wide voluntary participation of scientists
- Broadest possible review including complete paper trail
- Line-by-line approval

3) Interfacing science and policy: is the IPCC a blueprint for IPBES?

No:

- The targets are much more complex (or appear so)
- The use of other sources than peer-reviewed literature will be imperative

- (Some also argue that “biodiversity is more local than climate” – I find that misleading)

3) Interfacing science and policy: is the IPCC a blueprint for IPBES?

An urgent plea:

- The key foundation of IPBES will nevertheless be the published literature,
- written by scientists (e.g., from BiodivERsa projects)
- funded by national funding agencies

So do not wait to be asked for your contribution to IPBES – it happens now!

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4) Gaps of knowledge and what to do about them

Disclaimer #1: this is entirely biased by my own perspectives…

Disclaimer #2: for nearly everything here, there are already good examples – but we will need many more

4) Gaps of knowledge and what to do about them (#1)

- Observing change in biodiversity
  - across continents, regions, landscapes
  - across taxonomic units
  - in natural as well as managed systems
  - above ground, below ground, shallow sea, deep sea
  - essential:
    - training & knowledge base in systematics
    - free access to data

4) Gaps of knowledge and what to do about them (#2)

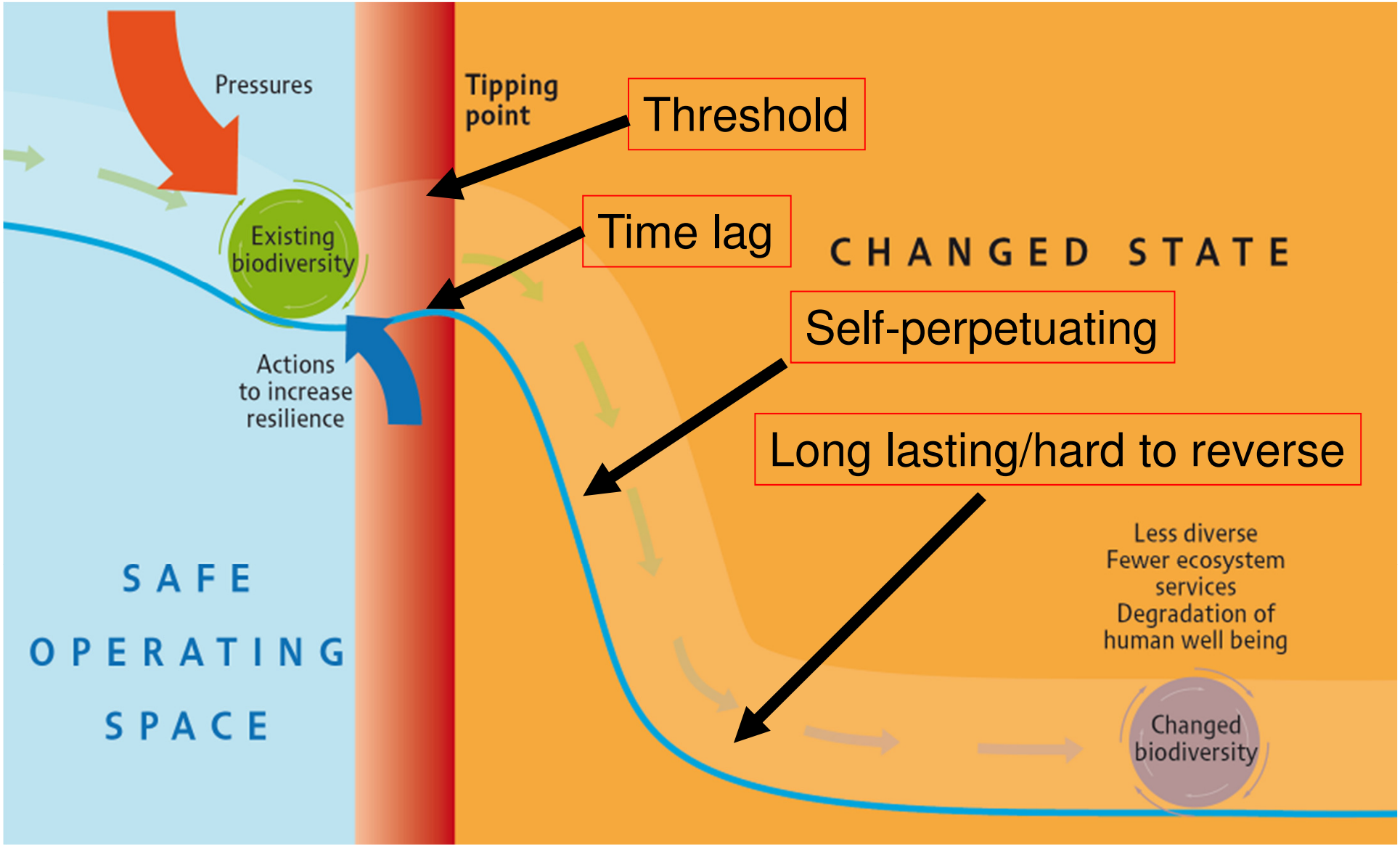
- The connection between biodiversity and ecosystem function
  - remains elusive: a fundamental “law” is unlikely to exist – instead we will perhaps need huge amounts of information
  - depends on the definition of “function” (the debate between “intrinsic” and “utilitarian” is maybe not helpful)

4) Gaps of knowledge and what to do about them (#3)

- Impacts of current drivers of global change on biodiversity and ecosystem function
  - crucial distinction between observed change and future sensitivities
  - crucial distinction between major drivers (land use, climate, invasive species)
  - needs to be unbiased and hence include positive effects as well
  - no laws – large number of studies required

Biodiversity Futures

What is a tipping point?



4) Gaps of knowledge and what to do about them (#4)

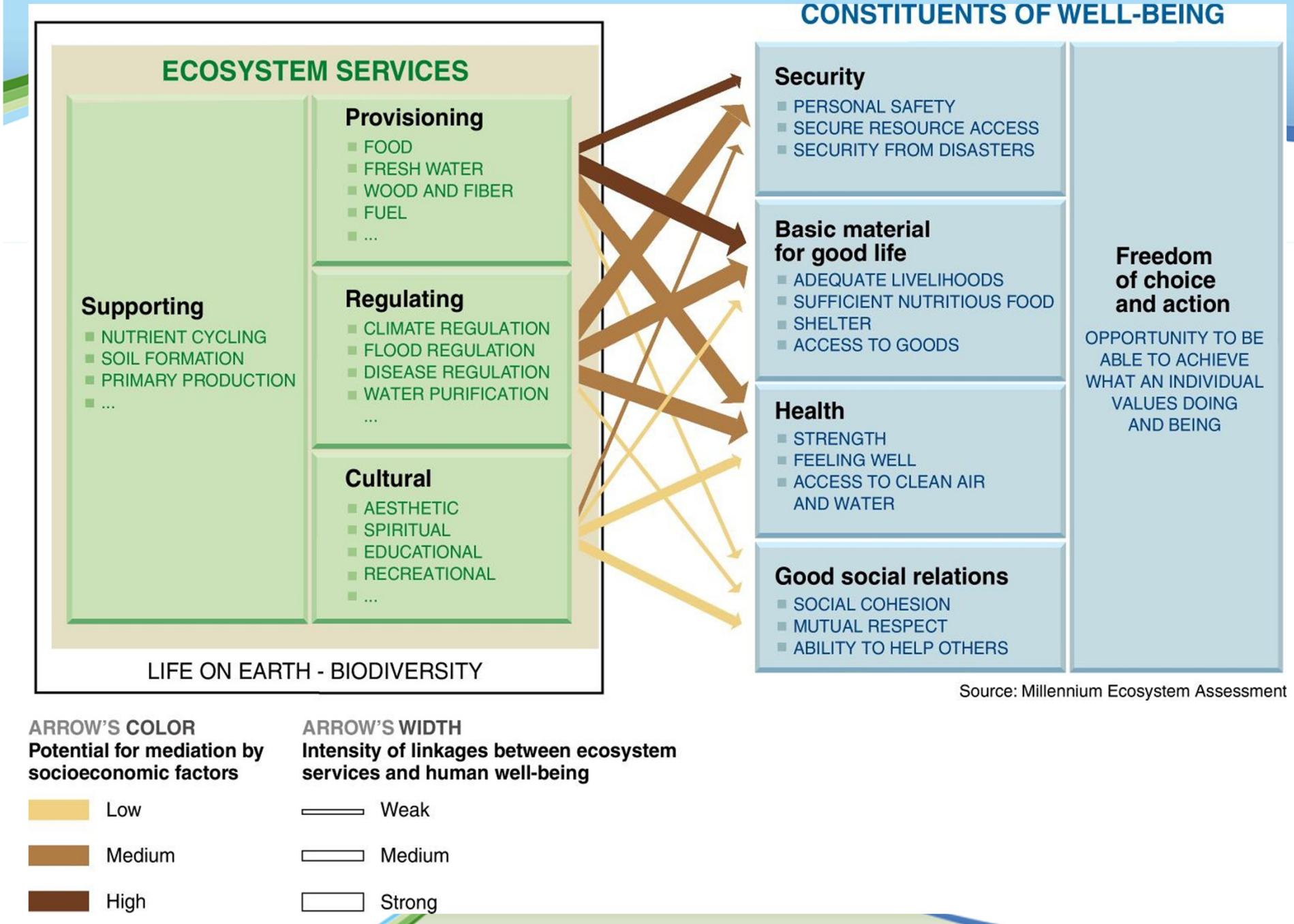
- Impacts of future drivers of global change on biodiversity and ecosystem function
  - risk assessment approach
  - probabilistic modelling
  - earth system interactions, feedbacks, nonlinearities, tipping points
  - uncertainty is not a problem but a part of the analysis

4) Gaps of knowledge and what to do about them (#5)

- Broad assessment of impacts of ecosystem change on society
  - monetary and non-monetary valuation of services
  - trade-offs, rebound effects

4) Gaps of knowledge and what to do about them (#6)

- Interactions between ecosystem change and societal dynamics
  - further development of basic paradigms (social ecology, resilience etc.)


ECOSYSTEM SERVICES
Provisioning
FOOD
FRESH WATER
WOOD AND FIBER
FUEL
...
Regulating
CLIMATE REGULATION
FLOOD REGULATION
DISEASE REGULATION
WATER PURIFICATION
...
Cultural
AESTHETIC
SPIRITUAL
EDUCATIONAL
RECREATIONAL
...
Supporting
NUTRIENT CYCLING
SOIL FORMATION
PRIMARY PRODUCTION
...
LIFE ON EARTH - BIODIVERSITY
CONSTITUENTS OF WELL-BEING
Security
PERSONAL SAFETY
SECURE RESOURCE ACCESS
SECURITY FROM DISASTERS
Basic material for good life
ADEQUATE LIVELIHOODS
SUFFICIENT NUTRITIOUS FOOD
SHELTER
ACCESS TO GOODS
Health
STRENGTH
FEELING WELL
ACCESS TO CLEAN AIR AND WATER
Good social relations
SOCIAL COHESION
MUTUAL RESPECT
ABILITY TO HELP OTHERS
Freedom of choice and action
OPPORTUNITY TO BE ABLE TO ACHIEVE WHAT AN INDIVIDUAL VALUES DOING AND BEING
Source: Millennium Ecosystem Assessment
ARROW'S COLOR
Potential for mediation by socioeconomic factors
Low
Medium
High
ARROW'S WIDTH
Intensity of linkages between ecosystem services and human well-being
Weak
Medium
Strong

4) Gaps of knowledge and what to do about them (#7)

- Outcome-oriented research, e.g.,
  - what societal action could generate a certain outcome for biodiversity and ecosystem function?
  - which win-win situations exist for biodiversity conservation and climate policy?

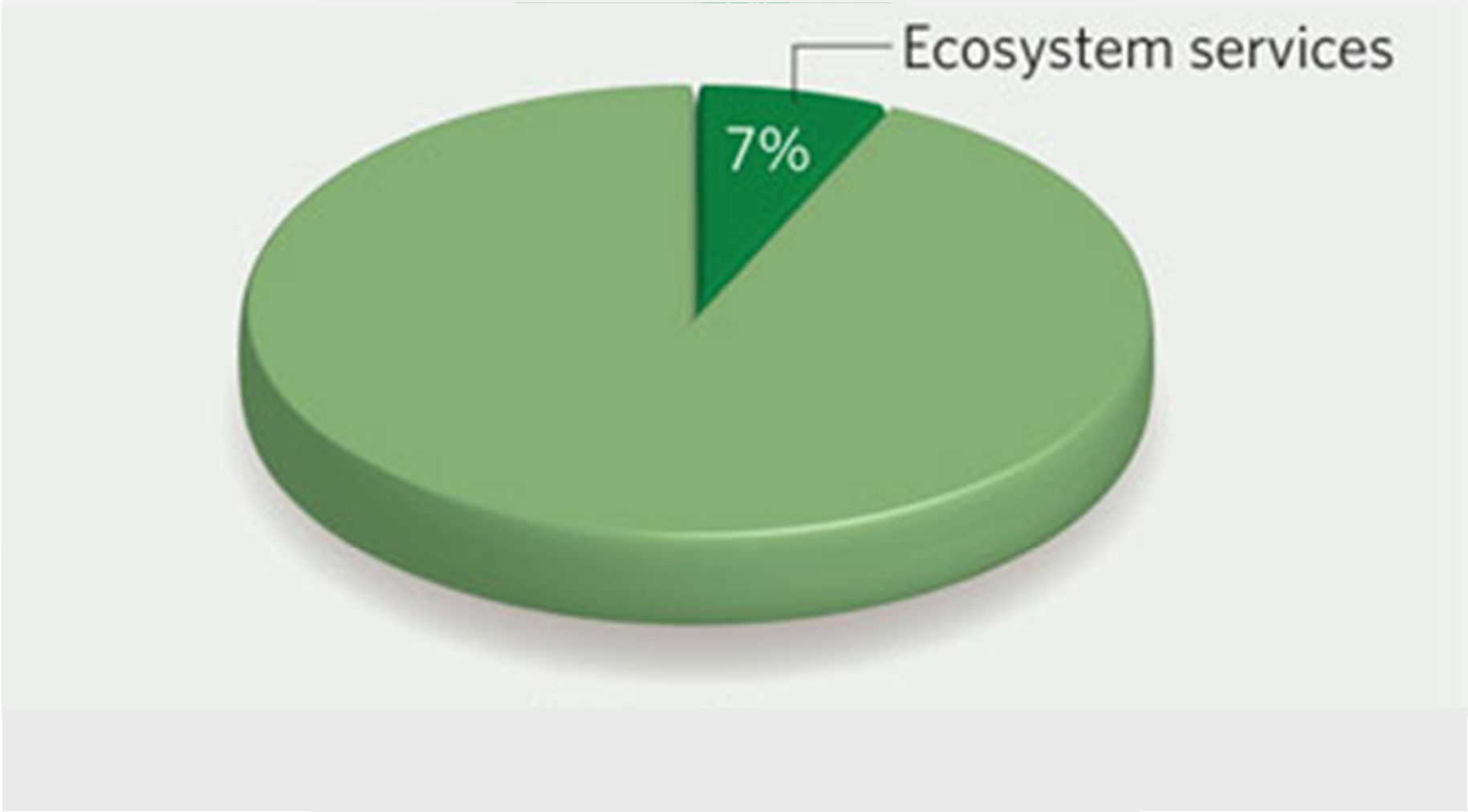
4) Gaps of knowledge and what to do about them (#8)

- Use of traditional ecological knowledge as validated support for policy

4) Gaps of knowledge and what to do about them (#9)

- Cultural, social and spiritual benefits of ecosystem function, characterized in ways that permit inclusion in trade-off analysis and priority-setting

ECOSYSTEMS AND POVERTY IN INDIA



4) Gaps of knowledge and what to do about them (#10)

- "Option values" – qualitative or quantitative characterization of possible future benefits from biodiversity

Ecosystem Service Assessment is reaching businesses and policy, so where are the next challenges for science?

1. A personal history of global change
2. Ecosystem service assessment, an established paradigm?
3. Interfacing science and policy: is the IPCC a blueprint for IPBES?
4. Gaps of knowledge and what to do about them
5. My personal wish list

5) My personal wish list

- Improvement of inventories and access to data
- Development of a true Earth System science, involving physics, biology, economics and social sciences
- Broadest possible support (by scientists and funders) to science-policy dialogue and communication to the public


Thank you very much for your attention!